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PHYSICS.—*A visibility equation derived from the Ives and Kingsbury new luminosity equation.* PAUL D. FOOTE, University of Minnesota.

In a recent paper Ives and Kingsbury[1] have found that the simple expression $L = 24000 \exp. - 1/(0.00250 + 0.00003795\ \vartheta)$ quite closely represents the relation between the luminosity L of a black body and its absolute temperature ϑ. It is interesting to enquire what function of the wave length λ the visibility must be to satisfy this equation of luminosity. We have:

$$L = \int_0^\infty V J\, d\lambda = \int_0^\infty V(\lambda)\, c_1 \lambda^{-5} e^{-\frac{c_2}{\lambda\vartheta}} d\lambda = A\, e^{-\frac{1}{a+b\vartheta}} \quad (1)$$

where $V(\lambda)$ represents the visibility, J = intensity as given by Wien's law, and the expression on the right is the new luminosity relation.

Equation (1) is a simple integral equation which may be readily solved for $V(\lambda)$. If one makes successively the substitutions $x = 1/\vartheta$, $ax + b = at$, $p = b/a$, $p' = p/a$, and

$g(s) = 2\pi i e^{1/s} A^{-1} c_1 c_2^{-4} V(\lambda) s^3 e^{ps}$, one obtains:

$$h(t) = e^{p'/t} = \frac{1}{2\pi i} \int_0^\infty g(s)\, e^{-ts}\, ds \quad (2)$$

[1] Phys. Rev., 8: 325. 1916.

Equation (2) may be solved for $g(s)$ by using the reciprocal integral (3) derived by Pincherle,[2]

$$g(s) = \int_c e^{st} e^{p'/t}\, dt \tag{3}$$

the integral starting at $-\infty$ below the axis of reals, encircling all singularities in the finite complex plane and ending at $-\infty$ above the axis of reals. On performing this integration and expressing $g(s)$ in terms of $V(\lambda)$ one obtains:

$$V(\lambda) = R\, e^{-\frac{c_2 b}{a\lambda}} \sum_{n=0}^{\infty} \left(\frac{b\, c_2}{a^2}\right)^n \frac{\lambda^{4-n}}{\lfloor\underline{n}\ \lfloor\underline{n-1}} \tag{4}$$

$$\text{where } R = A\, e^{-\frac{1}{a}} c_1^{-1} = \text{constant.}$$

If $c_2 = 14{,}350$ and the values of a and b obtained by Ives and Kingsbury are substituted in (4) the final visibility equation takes the form.

$$V(\lambda) = R\, e^{-\frac{217.8}{\lambda}} \lambda^4 \sum_{0}^{\infty} \left(\frac{87130}{\lambda}\right)^n \frac{1}{\lfloor\underline{n}\ \lfloor\underline{n-1}} \tag{5}$$

The series in (5) is of the form $\Sigma x^n / \lfloor n\ \lfloor n-1$ where x is over 100,000. The ordinary methods of making such a series more rapidly convergent, such as Euler's transformation, etc., do not appear to assist materially in the present instance, and it is not evident that (5) can be expressed in closed form. Accordingly unless (5) can be put in a rapidly convergent form its main interest is in the method of its derivation, this being the first example in which a visibility equation has been derived from a luminosity equation. The ordinary procedure is the converse of this.

[2] Mem. Accad. Sci. Ist. Bologna, IV, vol. 8.

GENETICS.—*The control of the sex ratio.*[1] OSCAR RIDDLE, Department of Experimental Evolution, Cold Spring Harbor, New York.

No better way to introduce a discussion of the present subject has occurred to me than to avail myself of the words—written less than three years ago—with which Professor Doncaster begins his very excellent book on *The Determination of Sex:*

> The question "Is it a boy or a girl?" is perhaps the first which is generally asked about the majority of mankind during the earliest hours of their independent existence; and the query "Will it be a boy or a girl?" must equally often be in the mind, even if it is less frequently expressed in words. This second question raises one of the most widely discussed problems of biology, that of the causes which determine whether any individual shall be male or female, and it suggests the still deeper question, "Why should there be male and female at all?" The problem of the nature and cause of Sex ranks in interest with that of the nature and origin of Life, and it may be that neither can be completely solved apart from the other. Notwithstanding the immense amount of brilliant speculation and research which has been devoted to the fundamental problem of Life, it must be admitted that hitherto no satisfactory solution has been found, and in some respects the question of Sex is equally obscure. Hardly any other problem has aroused so much speculation, and about few has there been such great divergence of opinion. In one direction, however, the last few years have seen a considerable advance, and we now know at least something of the causes which lead to the production of one or the other sex, although of the manner in which these causes act our ignorance is still profound.
>
> It is but a short step from the question "Is it a boy or a girl?" to the further question "Why is it a girl instead of a boy?" and yet until recently the answer to this latter question seemed hopelessly beyond our grasp, and even now, although some indications of an answer can be given, they do not touch the deeper problems of the real nature of sex. It is a remarkable thing that apart from the fundamental attributes of living matter—irritability, assimilation, growth, and so forth—no single character is so widely distributed as sex; it occurs in some form in every large group of animals and plants, from the highest to the lowest, and yet of its true nature and meaning we have hardly a suspicion. Other widely distributed characters have obvious functions; of the real function of sex we know nothing, and in the rare cases where it seems to have disappeared, the organism thrives to all

[1] A lecture delivered before the Washington Academy of Sciences, March 29, 1917.

appearance just as well without it. . . . . Sex, therefore, although it is almost universally found, cannot be said with certainty to be a necessary attribute of living things, and its real nature remains an apparently impenetrable mystery.

From the statements of this rather long quotation we shall have occasion, during the present hour, to dissent only from the impression that the problem of the nature of sex offers difficulties of a magnitude comparable with those touching the origin of life, and that its mysteries are apparently impenetrable.

Studies on the heredity of sex have indeed made great progress during the last fifteen years. These studies have been concerned with sex-linkage and with the so-called sex-chromosomes. Since Doncaster, whom I have quoted, is one of the foremost workers in both of these fields of study, it is particularly significant that, in his opinion, all of the results thus far obtained from breeding and cytology have thrown so little light on the real nature and meaning of sex, and that from further advances in these fields he apparently hopes for so little. For this reason—and another, namely that the relation of chromosomes to heredity and sex, have probably been extensively treated in other lectures of this series—you will, I trust, not now require a lengthy survey of the relations which the chromosomes are known to bear to sex, but will grant most of the present hour for an examination of the results obtained from studies of a quite different sort; namely, of experimental attempts to control the sex ratio, to learn the nature of sex, and to control the development of sex.

It is quite necessary, however, that all experimental studies on the control of the sex ratio should be carried out with the fullest recognition of the known *normal* association of the chromosome numbers—particularly of the sex-chromosomes—with sex, if the results of such studies are to be used toward a decision of the question whether sex itself has been reversed or controlled. The all-important question concerning abnormal or unusual sex ratios is, of course, the question of their meaning—Has a particular germ cell which had initial tendencies to produce one sex been experimentally forced to the production of the opposite sex? Or—a quite different thing—have the conditions of the

experiment decreased or suppressed the production, or hindered the union, or modified the chromosomal constitution, of one of the types of germ cell and left the other type normal and functional? These possibilities for accounting for abnormal sex-ratios certainly exist and they must be squarely met by decisive experiment. The facts from this sphere which we shall most need to bear in mind while examining our series of ratios are as follows:

1. Sperm and ovum are two kinds of sex cells in respect of their origin from the two contrasted sexes; but, beyond this, it is now clear that in some animals one and the same male produces spermatozoa of two kinds, and that these two kinds are not equal in their prospective sex value. Still other animal forms are known in which the female produces two kinds of eggs, having opposite prospective sex value. Most groups of insects and several mammals are known to produce two kinds of sperm, while in moths (Lepidoptera) and birds the dimorphism of the germs exists in the eggs.

2. In forms which reproduce in part parthenogenetically—such as the bee, gall fly, plant-louse, etc.—the sex is known to bear certain relations to chromosome number, or to maturation phenomena in the egg.[2]

3. In wide crosses among Echinoderms, Baltzer ('09) and Tennent ('12) have shown that when the cross is made in one of the two possible directions, some of the chromosomes proceeding from the sperms are eliminated and do not take part in embryo-formation. This type of chromosome behavior has been found, however, only in crosses of very widely separated forms.

Pure wild species of doves and pigeons have proved to be almost ideal material for obtaining highly abnormal sex-ratios, and for the analysis of the meaning or significance of the modi-

[2] Even if one fully concedes the "lethal factor" explanation which Morgan (Science, N. S. **36**: 718. 1912) gives for a particular ratio (1 ♂: 2 ♀) in Drosophila, a similar basis could not apply to most of the pigeon series, since here *every* egg formed in the ovary can be accounted for, and in numerous series *every* egg hatched. These same facts, together with the fact that it is the female pigeon that is heterogametic, exclude the action of "assortative mating" as a cause of the sex-ratios obtained in the pigeon.

fied ratios. And since it has now been shown (we shall here attempt to demonstrate the point) that a real reversal or control of sex has been effected in these forms, the large and dimorphic ova found generally in doves and pigeons have permitted new lines of investigation on the nature of sex itself. As a final result of these studies—a result that we may very briefly indicate in advance of the presentation of the data—we believe that it is now reasonably clear that the two sexes are in fact the

TABLE 1

ON THE RELATION BETWEEN "WIDTH OF CROSS" AND THE SEX RATIO

MATINGS	WIDTH OF CROSS	NO. ♂	NO. ♀	SEX-RATIO
Columba × orientalis	Families	15	1(?2)	15.00:1 (or 7.50:1)
Alba × orientalis (spring—before July 1)	Genera	28	10	2.80:1
Alba × orientalis (average)	Genera	58	43	1.35:1
Orientalis × alba	Genera	36	33	1.09:1
Average reciprocal crosses	Genera			1.22:1
Turtur × orientalis, average reciprocal crosses	Species	14	18	0.78:1
Unrelated orientalis	Same species	36	34	1.06:1
Inbred orientalis	Same species (−)	18	20	0.90:1

expression of the rate of protoplasmic activity—of metabolism—pitched at two different heights or levels. For the pigeon world the data seem quite conclusive, and when we shall have reviewed a part of these data we will undertake to place before you the experimentally modified sex ratios obtained elsewhere among animals, in an attempt to show that this considerable body of evidence supplies further confirmation, and only confirmation, for the modifiability of sex, and for our conclusion that the male sex is an expression of metabolism at a higher level, the female sex of metabolism at a lower or more conservative level.

The work which first showed the remarkable suitability of the wild pigeons for the analysis of the sex-problem was done by the late Professor Whitman who devoted many years to the study of these forms. Whitman obtained indisputably a profound modification of the sex-ratio, and identified in a general way some factors associated with the modified ratios. Whether

TABLE 2

SEX RATIOS AND "WIDTH OF CROSS" AS REPORTED BY VARIOUS AUTHORS

AUTHOR	CROSS	= DIFFERENT	♂:♀
Buffon[a]	Goat × sheep	Species	7: 2
	Dog × wolf	Species (?)	3: 1
	Gold-finch × canary	Species	16: 3
Suchetet	Various[b]	Genera	74: 13
	Various[b]	Species	72: 18
	Tetrao	Species	40: 8
	Lagopus × Tetrao	Genera	13: 7
Phillips	Ducks	Races	46: 24
Guyer[c]	Guinea × chicken	Sub-fam.	6: 0
	Pheasant × chicken	Sub-fam.	12: 0
	Peafowl × chicken	Sub-fam.	2: 0
	Peafowl × peafowl	Genera	1: 0
	Pheasant × pheasant	Genera	14: 1
	Pheasant × pheasant	Species	12: 3

Totals: s. fam. 20.0: 0; gen. 4.9: 1; sp. 4.3: 1; rac. 1.9: 1

[a] Cited by Suchetet and by Guyer.

[b] As summarized by Guyer from Suchutet's studies on museum specimens.

[c] Guyer's figures refer not to breeding data, but to the specimens available in various museums (British, Paris, etc.).

the modified ratios signified a real control—a reversal—of sex could not at that time be definitely decided. But on this question he obtained three kinds of evidence, to be mentioned later, and all of these indicated true sex-reversal.

Whitman showed that "width of cross" in doves and pigeons is of first importance in determining sex ratios in hybrid pig-

TABLE 3

FERTILITY IN "FAMILY" AND "GENERIC" CROSSES

FAMILY CROSS			GENERIC CROSS		
Common × ring			Ring × turtle		
A1	6- 9-15	infert.	D1	4-27-07	*infert.*
A2	6-11-15	infert.	♂D2	4-29-07	hatch.
♂B1	6-23-15	*hatch.*	♂E1	6- 2-07	hatch.
♂B2	6-25-15	*hatch.*	♂E2	6- 4-07	hatch.
C1	7- 1-15	infert.	♀F1	7-14-07	hatch.
C2	7- 3-15	infert.	♀F2	7-16-07	hatch.
D1	7-28-15	infert.	♂G1	8-25-07	hatch.
D2	7-30-15	infert.	♀G2	8-27-07	hatch.
E1	8-13-15	infert.	♂A1	2-12-08	hatch.
E2	8-15-15	infert.	♀A2	2-14-08	hatch.
F1	9-10-15	infert.	♂B1	3-18-08	hatch.
♂F2	9-12-15	*hatch.*	♂B2	3-20-08	hatch.
G1	9-26-15	infert.	♀C1	4-17-08	hatch.
G2	9-28-15	infert.	♀C2	4-19-08	hatch.
H1	10-10-15	infert.	♀D1	5-23-08	hatch.
H2	10-12-15	infert.	♀D2	5-25-08	hatch.
I1	10-21-15	infert.	♀E1	6-26-08	hatch.
♂I2	10-23-15	*hatch.*	♀E2	6-28-08	hatch.
J1	11-15-15	infert.	♀F1	8- 9-08	hatch.
J2	11-17-15	infert.	♀F2	8-11-08	hatch.
K1	12-13-15	infert.	♀G1	9-20-08	hatch.
K2	12-15-15	infert.	♀G2	9-22-08	hatch.
L1	12-28-15	infert.	♂A1	3- 2-09	hatch.
L2	12-30-15	infert.[a]	♀A2	3- 4-09	hatch.

[a] All of the succeeding 64 eggs produced by this pair—under continued "overwork"—have been tested for fertility. Of these 62 were wholly infertile; the other two hatched (both are males).

eons and that the wider the cross the higher is the proportion of males. Family crosses produce, in nearly all matings, only male offspring. Generic crosses produce from their "stronger" germs—those of spring and early summer—nearly all males. If, however, the birds of such a generic cross be made to "overwork at reproduction," that is if their eggs are taken from them as soon as laid and given to other birds for incubation, then the same parents which in the spring threw all or nearly all male offspring may be made to produce all, or nearly all, female offspring in late summer and autumn. At the extreme end of the season eggs capable of little, then of no development, are often found in such series. As the parent birds grow older the time of appearance of females, and of eggs incapable of full development, is reached earlier and earlier in the summer or spring.

The relation of "width of cross" to the sex ratio in one of the many species (*Turtur orientalis*) with which he worked is summarized[3] in Table 1. Practically every gradation from the widest possible (family) cross to inbreeding shows a sex ratio in accordance with its position in the series.[4] The "family cross" shown in Table 3 has also produced only males.

In Table 2 I have grouped according to width of cross a number of sex ratios reported by various observers. Here again it is found that family crosses yield only male offspring (20 ♂ : 0 ♀); generic crosses a ratio of 4.9 ♂ : 1 ♀; specific crosses 4.3 : 1; racial crosses 1.9 : 1. The normal sex ratio, i.e., the ratio for any of these species mated to its own kind, is probably nearly 1 : 1 or at most not higher than 1.3 ♂ : 1 ♀. The method of collecting most of these data renders then objectionable as evidence on some important questions, and the numbers are small, but they certainly support the generalization that as the "width of the cross" is increased a relatively higher proportion

[3] The matings included in this table were continued by the present writer; both earlier and later work (to 1914) are included in the summary.

[4] The specific cross—*T. turtur* and *T. orientalis*—whose ratio (0.78 : 1) is a seeming exception is in reality not an exception. One of the females used in this cross had been previously "overworked" and threw nearly all females as a consequence. For complete data see C. O. WHITMAN, Posthumous Works, Vol. II, chap. 4. The Carnegie Institution of Washington. (In press.)

TABLE 4

BREEDING RECORDS—1914

(St. alba ♂ ×) ♀ St. risoria 641 (old); 1913 = 42 eggs.

Series 1

♀A1	1- 1	White 140
♀A2	1- 3	White, dead 2-3
1st (4) = 2.066 g. 2d (4) = 2.243 g.		
H1	4- 4	Inf. yolk = 1.995 g.
H2	4- 6	Inf. yolk = 2.105 g.
♀I1	4-12	White, killed 4-29
♀I2	4-14	White 158 (?2)
♂J1	4-21	Dark, killed 2-25
♀J2	4-23	White 158
♀K1	4-29	White 147
♀K2	5- 1	White 151
L1	5- 9	Broken
?♂L2	5-11	Dark (disap.?)
♂M1	5-18	Dark 161(?1)
♀M2	5-20	White 163
♀N1	5-30	White 150
♀N2	6- 1	White, killed with ext.
♂O1	6- 7	Dark 150
♀O2	6- 9	White 150
♂P1	8-18	Dark 149
P2	8-20	Broken
♀Q1	6-28	White 143
♀Q2	6-30	White 137
♀R1	7- 4	White 154
♂R2	7- 6	Dark 162
?♂S1	7-12	Dark, dead 7-29
♀S2	7-14	White, dead 7-31
♀T1	7-20	White 140
♂T2	7-22	Dark 164
♀U1	7-28	White 144
♀U2	7-30	White 151
♀V1	8-14	White 155
♂V2	8-16	Dark 169
♀WI	8-22	White 152
W2	8-24	Soft at pole
♀XI	8-30	White 161
♀X2	9- 1	White 145
♂Y1	9- 9	Dark 161
♀Y2	9-11	White, killed bef. 10-12
♀Z1	9-18	White
♀Z2	9-20	White, dead 10-26
♀AA1	9-26	White 141
♀AA2	9-28	White 146
♀BB1	10- 7	White 150
♀BB2	10- 9	White 144
?♀CC1	10-17	Dark, dead 11-8
♀CC2	10-19	White, dead 11-10
♀DD1	10-26	White 130 (?1)
♀DD2	10-28	White 162 (?2)
♂EE1	11- 6	Dark 152
♀EE2	11- 8	White 143
♀FF1	11-16	White 166
FF2	11-18	Broken
♀GG	11-26	White dead 150
♀HH1	12- 7	White
♂HH2	12- 9	Dark, dead 1-9-15
♀II1	12-20	Dark, dead 11-6-15
♀II2	12-22	White, 9 da. embr.

1st 17 = 5 ♂: 12 ♀; 2nd 17 = 4 ♂: 13 ♀; last 17 = 2 ♂: 15 ♀

of males is produced. It may be noted in passing that this generalization touches the question of the nature of sexual difference; for, studies among the most diverse animals and plants have afforded evidences of the "increased vigor of hybrids," of what Darwin called the "good effects of crossing," and of what has been observed in Mendelian breeding as the "greater vigor of the heterozygote." The means of "increasing the vigor" of the offspring are, therefore, the very same means by which higher and higher proportions of males are obtained; and males, we have concluded from other studies, are characterized by a more active metabolism than that found in females.

A glance at Table 3 will assist in making clear some of the advantages which the pigeons afford in the analysis of sex ratios. First, examining the details of the "family cross"—it is an exceptionally bad history with almost complete infertility—we note that only males are produced, but that a very great number of eggs failed completely to develop. It might be contended that in such a series only the male-producing eggs are fertilized, and for this reason only males are produced. We may fully grant the point; though attention should be directed to the fact that if this were the *whole of the story* it is rather remarkable that only 4 eggs of the 18 here shown (6 of 88 in the entire series) were fertilized, since it can be proved in any similar series that at least half of the 18 eggs (also half of the 88) were male-producing eggs. And a further point of interest is that while 4 of the first 18 eggs were fertile only 2 of the last 70 eggs—produced under overwork, or crowded reproduction—were fertile. But to recur to the original point—the pigeon in any event affords an opportunity to study the *total production* of the animal's ovary; and this particular animal's ovary contains all of the sexually differentiated germs.

In the second section of Table 3 are given the details of a *generic* cross, a cross of less widely departed forms than in the preceding case. In these crosses practically every egg can be hatched and the sex of the resulting offspring learned. This was done in 23 of the 24 eggs here recorded. This particular record is one of the many made by Professor Whitman from which he

TABLE 5

BREEDING RECORDS—1914

(St. alba ♂ ×) ♀ St. risoria 647 (young); 1913 = 18 eggs

Series 2

A1	1- 9	Wt. yolk = 1.515 g.
A2	1-11	Wt. yolk = 1.595 g.
B1	1-28	Wt. yolk = 1.590 g.
B2	1-30	Wt. yolk = 1.685 g.
C1	2- 8	Inf. yolk = 1.445 g.
C2	2-10	Broken
♂D1	3- 5	Dark 8-da. embr.
♀D2	3- 7	White
♂E1	3-19	Dark 167
♂E2	3-21	Dark 180
♀F1	3-29	White 154
♂F2	3-31	Dark 190
♂G1	4- 8	Dark, killed 5-6
♀G2	4-10	White, killed 5-3
♀H1	4-16	White 153
♀H2	4-18	White 153
♂I1	4-25	Dark 169
♀I2	4-27	White 154
J1	5- 5	3-da. embr. killed
J2	5- 7	3-da. embr. killed
♂K1	5-14	Dark 169
♀K2	5-16	White 158
♂L1	5-25	Dark 179
♀L2	5-27	White 164
♂M1	6- 3	Dark 169
♀M2	6- 5	White 11-da. embr.
♂N1	6-13	Dark 165
♀N2	6-15	White 150
♂O1	6-22	Dark, killed 7-13
O2	6-24	Wt. yolk = 1.968
♀P1	7- 1	White 150
♀P2	7- 3	White 15-da. embr.
♀Q1	7- 9	White 148
♂Q2	7-11	Dark 164
♀R1	7-22	White 152
♂R2	7-24	Dark 172
?♀S1	8- 3	White 13-da. embr.
S2	8- 5	Broken 3-da. embr.
♂T1	8-12	Dark 174
♀T2	8-14	White 164
U	8-20	Yolk = 1.490 g.
V1	9- 6	"Blood circle"
♂V2	9- 8	Dark 170
?♂W1	9-19	Dark, dead 10-16
♀W2	9-21	White, dead 10-14
♂X1	9-30	Dark, dead 10-19
♀X2	10- 2	White 145
Y1	10-29	Inf. yolk = 1.845 g
♀Y2	10-31	White 15-da. embr.
Z1	12-27	No dev. yolk = 1.870 g.
Z2	12-29	No dev. yolk = 1.925 g.

♀641 = (170 g.) (♂ 170 g.)
♂'s (5) from 1st = 155 g. ♀'s (13) = 149 g.
♂'s (3) from 2nd = 165 g. ♀'s (11) = 150 g.

♀647 = (166 g.) (♂165 g.)
♂'s (7) from 1st = 170 g. ♀'s (5) = 151 g.
♂'s (5) from 2nd = 175 g. ♀'s (6) = 158 gr.

1st 18 = 9 ♂: 9; ♀ 2nd 18 = 8 ♂: 10♀; (1915 = 11 ♂: 21 ♀)

learned the following facts: (1) Generic crosses, when not permitted to lay many eggs, produce mostly or only males. (2) Such pairs, when made to lay many eggs (crowded reproduction) produce males predominantly from their earlier, stronger eggs, and predominantly or only females from the later eggs laid under stress of overwork. (3) From the eggs of pure wild species the first egg of the pair or clutch more often hatches a male; the second egg of the pair more often produces a female.

These generic crosses, then, show practically full fertility and exclude the possibility of accounting for the abnormal sex ratio of either spring or autumn by any "assortative mating" of germs, since the sperms by hypothesis are all alike,[5] and *all* of the ova are fertilized and the resulting sex of all is known.

From series of eggs produced by generic crosses, under "overwork" it is therefore practicable to select a certain number of eggs from near the first and from near the last of the season, and have fair assurance that (in this type of mating) most if not all of the earlier lot are prospectively male-producing, and most or all of the later lot are female-producing eggs. It was this possibility that enlisted my own first efforts in the study of sex. And, since a single individual ovum or yolk of the pigeon is large enough to permit a chemical analysis—our first study was to determine whether possible chemical differences between the male and female-producing ova exist and are discoverable. The first analyses of the pigeon's ova were made in April, 1911, and the work has been carried on continuously since that time. Nearly 900 individual yolks have now been analyzed. Among these are represented the eggs of several pure species, and of many kinds of hybrids. The records for the chemical composition of the egg-yolks of a considerable number of individual females is now complete for five consecutive years. Altogether, these studies, and the supplementary ones which developed out of them or along with them, have brought to light a number of facts which I can here only briefly sketch.

Before considering the results of the analyses it may be well to make clear the nature of a difference which appeared as soon

[5] It is certain that the ova are sexually dimorphic.

as my first lots of yolk samples were placed on the balances for the preliminary weighings. The balances alone and at once showed that the *mass* of the yolk of the first egg of nearly all pairs of eggs (from pure species) was less by from (usually) 9 per cent to 15 per cent than the mass of the yolk of the second

TABLE 6

WEIGHT OF ENTIRE EGGS, AND OF YOLKS, 1913–1915 OF ♀ 641 and ♀ 647

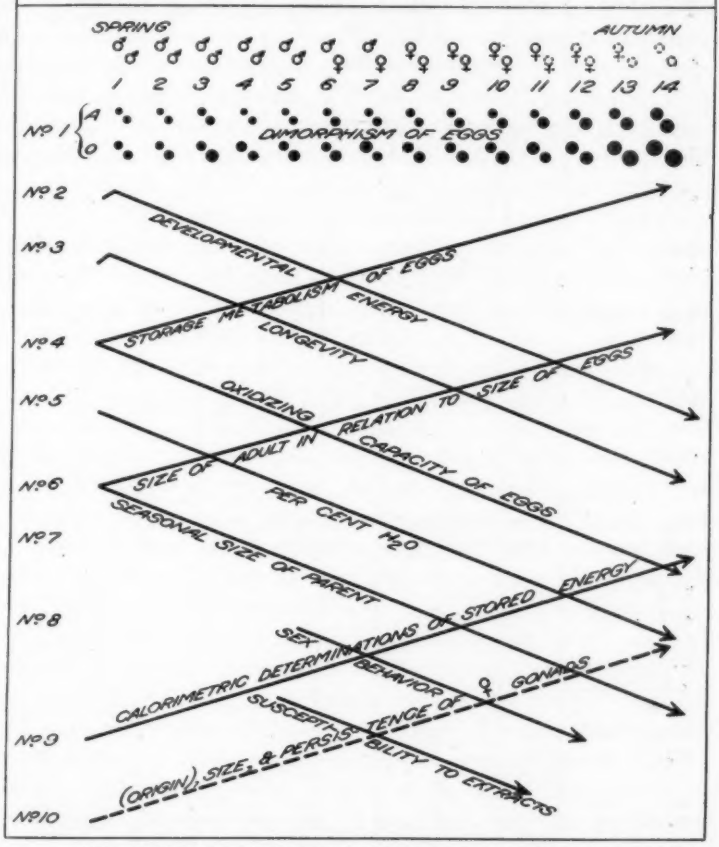
YEAR	TOTAL EGGS PRODUCED	EGGS. ord. no. wt. + hr.[a]	YOLKS no. wt. + hr.	SEX ♂ : ♀
		♀ 641 (older)		
1913	(42)	1st (19) = *8.532* + 25½	(5) *1.903* + 15½	♀ ♂: 8 ♀ : 1 ♂ ♀
		2nd (19) = *9.221* + 16	(6) *2.153* + 20½	
1914	(67)	1st (30) = *8.627* + 6½	(4) *2.032* + 139	11 ♂ : 40 ♀
		2nd (31) = *9.275* + 1½	(5) *2.219* + 106	
1915	(16)	1st (7) = *8.584* + 6	.....	6 ♂ : 8 ♀ (*all early*)
		2nd (7) = *9.290* + 1	.....	
		♀ 641 dead 4-17-15	Total.....	26 ♂ : 56 ♀
		♀ 647 (younger)		
1913	(18)	1st (6) = *7.246* + 6	(2) *1.482* + 11	1 ♂ : 6 ♀ (*all late*)
		2nd (5) = *8.062* + 2	(2) *1.535* + 3½	
1914	(51)	1st (25) = *7.478* + 9	(5) *1.653* + 70	17 ♂ : 19 ♀
		2nd (24) = *8.403* + 4	(4) *1.793* + 59	
1915	(45)	1st (22) = *7.624* + 11	(1) *1.715* + 166	11 ♂ : 21 ♀ 1 (?)
		2nd (22) = *8.481* + 3	(1) *1.970* + 171	
		♀ 647 dead 2-16-16	Total.....	29 ♂ : 46 ♀

[a] The entire egg *loses* weight on standing; the yolk *gains* weight on standing.

egg of the pair. There were occasional reversals of this relation and also occasional pairs with quite nearly equivalent weight. In the eggs produced by hybrids this relation did not obtain at all. Illustrations of these differences in weight between the egg-yolks of first and second egg of the clutch may be seen in any of

CHART 1.

SEX CONTROL AND KNOWN CORRELATIONS IN PIGEONS.



No 1 SHOWS COMPARATIVE SIZE OF EGGS OF *ALBA* (A) AND *ORIENTALIS* (O).

TABLE 7

SUMMARY OF PARALLEL BREEDING AND CHEMICAL STUDIES ON THE EGGS OF ♀ *T. orientalis* No. 500 × *St. alba* No. 410—FOR THE YEAR 1912

DATE	AN'L'S OR INC.	WT. OF YOLK	ALC. SOLU-BLE	RESULT					
				Phos-phatide	Pro-teins	Ext.	Ash	H_2O	Energy total
4-13			Broken when found						
4-15			Broken when found						
5-26	159	2.330	72.65	18.32	25.44	5.28	4.85	57.01	7405
5-28	160	2.660	72.45	17.54	25.63	5.25	2.62	54.82	8990
6- 7	Inc.		Only one egg laid.			.....	.....	.....	Dark ♂
6-15	Inc.		.....			.....	.....	.....	Dark ♂
6-17	Inc.		"Very large egg".			.....	.....	.....	White ♀
6-24	Inc.		.....	.....	.....	.....	.....	.....	No dev.
6-26	Inc.		.....	.....	.....	.....	.....	.....	Dark ♂
7- 3	186	2.026	71.95	16.49	26.00	3.63	2.43	56.05	6714
7- 5	187	2.330	72.27	19.18	26.55	3.75	1.93	55.22	7881
7-15	Inc.		.....	.....	.....	.....	.....	.....	Dark ♂
7-17	Inc.		.....	.....	.....	.....	.....	.....	Dark ♂
7-23	192	2.422	72.42	17.82	25.88	3.82	1.80	55.84	8061
7-25	193	2.720	72.45	18.88	25.96	3.86	1.81	55.33	9296
8- 2	Inc.		.....	.....	.....	.....	.....	.....	Dark ♂
8- 4	Inc.		.....	.....	.....	.....	.....	.....	Dark ♂
8-13	Inc.		.....	.....	.....	.....	.....	.....	No. dev.
8-15	Inc.		.....	.....	.....	.....	.....	.....	Dark ♂
8-23	Inc.		.....	.....	.....	.....	.....	.....	No dev.
8-25	Inc.		.....	.....	.....	.....	.....	.....	White ♀
9-15	Inc.		.....	.....	.....	.....	.....	.....	White ♀
9-17	Inc.		.....	.....	.....	.....	.....	.....	White ♀
11-29	259	2.700	73.17	21.40	[a]25.23	.....	.....	55.52	9323
12- 1	260	2.715	73.02	21.63	[a]25.38	.....	.....	55.39	9383

[a] Calculated.

the appended tables in which yolk weights are given (Tables 4, 5, 6, 7, 8).

Other facts concerning the yolk weights which soon came to light were, that the yolks from an individual bird become larger in the autumn, particularly if the bird is made to lay numerous eggs (i.e., overworked) during the season. A schematic representation of the dimorphism of the ova, and of their increase in size from spring to autumn is shown (under 1) in Chart 1. A further fact of kindred nature was learned when the study was extended over a period of years, namely that the egg-yolks of an individual bird tend to become larger as the bird grows older; the yolks of the spring, however, are usually smaller than those of the previous autumn, though larger than those of the previous spring (Table 6). These facts are now established by accurate weighings of more than 12,000 yolks, freed and separated from their surrounding shell and albumen.

The details of the chemical analyses of one series of eggs obtained in 1912 are given in Table 7. These details we need not here consider, but it will be observed that we find larger amounts of the various chemical fractions (excepting water) in the female-producing egg than in the male-producing egg. This holds true alike for the female-producing egg of the clutch, and for the late eggs, which under these conditions are predominantly female-producing, as compared with the group of earlier eggs which under the conditions of the generic cross are relatively male-producing.[6] Not only does the size of the egg increase with its later position in the series, i.e., with lateness of season, as shown by a mere comparison of the yolk weights of such a series of eggs, but the percentage of energy-yielding or stored materials increases as much, or probably more, than is indicated by the size, or net weight of the yolk. The per centage of water, we shall later see, is greater in the male-producing eggs.

For our present purpose the importance of the results of these and other analyses is that they conclusively show: (1) that the

[6] In this particular series, 8 of the first 9 eggs incubated produced males; the egg of this group that hatched a female was "a very large egg." The last three hatches were females.

male-producing egg of the spring is an egg that *stores* less material than does the female-producing egg of the autumn. (2)

TABLE 8

STORED ENERGY OF EGGS (1914) OF *Streptopelia risoria* (♀ 558) AS DETERMINED BY THE BOMB CALORIMETER

NO.	DATE	WT. OF YOLK	ENERGY	PER CENT DIFF.
665	A1 6- 6	[a]1.010	[a]3,358	
666	A2 6- 8	0.970	3,175	[b]− 5.8
674	B1 6-19	0.855	2,807	
675	B2 6-21	1.000	3,245	+15.6
699	C1 7-14	1.145	3,815 ?	
700	C2 7-16	1.463	5,008	+31.3 ?
728	D 8-30	1.395	4,812	
...	E 9- 9 or	10 soft shell, broken.		
...	F1 10-17	soft shell, broken		
...	F2 10-19	soft shell, broken		
770	G1 11- 6	1.440	4,837 (?)	
771	G2 11- 8	1.720	5,797	+19.8 ?
774	H1 11-20	1.590 + sl. loss	4,906 +	
775	H2 11-22	1.780	6,015	+22.6 ?
776	I1 12- 1	1.640	5,614	
777	I2 12- 3	1.820	6,255	+11.4
781	J1 12-12	1.535	5,302	
782	J2 12-14	1.690	5,601	+ 5.6
791	K1 12-23	1.485	5,266 (?)	
792	K2 12-25	1.718	5,880	+11.7 ?

[a] This egg was not only the first laid during season, but first during life of this bird.

[b] The percentage differences are based upon a value of 100 per cent for the smaller egg of the pair.

That the male-producing egg of the clutch *stores* less material than does its female-producing mate. (3) That the eggs of old

females *store* more materials, and—as has been noted—yield a higher percentage of females, than do birds not old.[7] Therefore, it is evident that the egg of female-producing tendency is one whose *storage* metabolism is high, as compared with eggs of male-producing tendency. Moreover, the analyses show that during the season successive clutches present higher and higher storage, i.e., the earlier clutches store less—are more male-like; the later ones all store more—are more female-like—and as already noted the eggs of the low storage period give rise (in the generic cross) to males, and those of the high storage period produce females.

We here obtain a close view of that upon which sex difference rests. And the facts are now quite beyond question. Unmistakably, less storage and high storage pertain respectively to the male- and female-producing germs. Unmistakably, our procedures, connected with generic cross, season, and overwork, delivers males from the smaller storages in the earlier eggs. Unmistakably, the procedures raise the storage in all of the later eggs, and unfailingly we then find that these eggs yield only, or predominantly females. And if we eliminate the factor of wide (generic) cross and mate the female with one of her own or a very closely related species (Table 5), then we see that the production of males and females coincides from the first with two storage values—with two sizes of eggs (yolks) in the clutch—males from the smaller first, females from the larger second. Only after overwork and season have raised the storage value of the eggs is this situation seriously disturbed. And the disturbance—associated with an increase in the storage metabolism of all the eggs—delivers as before, an excess of female offspring (Tables 4, 5, 6).

The progressive *increase* in *storage* capacity of the eggs during the season—under overwork—is to be interpreted as a *decrease* in the *oxidizing* capacity of these same eggs. Living cells in general dispose of ingested food material by storing it or by burning it. If oxidized the products of the oxidation are removable and do not serve to increase the bulk of the cell. The

[7] See Tables 4, 5, 6.

low-storage capacity of the male-producing eggs as compared with the *high storage capacity* of female producing eggs is therefore an index of *higher oxidizing capacity* or as more usually stated, a *higher metabolism* of the male-producing eggs as compared with the female-producing eggs.

We may next examine the percentages of water in the eggs of spring and autumn, and in the two eggs of the clutch. These figures for one series of analyses are given along with other analytical results in Table 7. They show a higher water content for the eggs of the spring (male-producers). Indeed, each pair of eggs from the first of the season onward has a slightly higher moisture value than the pair that follows it. The analyses further show a higher percentage of water in the first egg of the clutch, i.e., in the male-producer, than in the second or female-producer in all cases.

If the results of my nearly 900 analyses all ran as smoothly as do the 8 of this series there would be no doubt of a perfect correlation of high moisture values with small eggs, i.e., with male-producing eggs—both small eggs of season, and small eggs of individual clutches. The results throughout, however, are not so uniform and smooth as here; there are some series which seem seriously to depart from the order noted above. These cannot be adequately discussed here. We can, however, record our own belief that the situation represented in the table is, in the main, indicated by the moisture determinations obtained in the analyses of eggs produced by pure species. Two additional methods of determining the amount of water in the yolks, give a satisfactory confirmation of the conclusion that the male-producing ovum contains a higher percentage of water than does the female-producing ovum.

It may be remarked at once that the two facts—a higher metabolism, and a higher water value in the same egg (the male-producing one)—are not to be regarded as a mere coincidence. They are related facts, essentially correlated in that the more hydrated state of these colloids, which contain only 54 to 59 per cent water, is certainly a more favorable state for a higher rate of (oxidizing) metabolism than is the less hydrated

state which better corresponds to a condition favorable to increased *storage.*[8]

The results of these analyses (as well as the calorimetric determinations to be mentioned later) have an important relation to the question of a modified or differential maturation, by which the changed ratios might be explained. Bearing on this point we may here make the following observations: It has been seen that the sex actually realized corresponds in fact to levels or grades of metabolism; and we now note that the (storage) metabolism which was measured *was complete before the beginning of maturation,* so that if such a differential maturation should occur it must be looked upon not as a *cause* but rather as a *result* of the establishment of that *grade of metabolism* which does here, and under all of the several known conditions, in the clearest way accompany and correlate with each particular sex.

But, any assumption of a differential maturation, even as a result of or response to these impressed levels of metabolism, brings with it more difficulites than it clears up. Among these it brings the paradox of a rigid selection *in favor of* the male-producing chromosome-complex in the maturations of the spring, and an equally rigid selection *against* this same complex in the autumn. Again, it is easily shown by simple breeding tests that such differential maturation does not occur in the spring at least when the female is mated to her own or a closely related species; so that a further assumption would have to be made to the effect that it is the *prospective* fertilization by a sperm from a wider cross that determines the course of maturation! Furthermore, our data on the sex-behavior of series of females from such a wide (generic) cross show that if the male-producing complex was indeed eliminated from the eggs that gave rise to one-half of these females (produced under overwork) these same chromosomes cannot be the real or sole cause of

[8] For example, Overton found that withdrawal of water from the cells of Spirogyra was followed by an increased *storage* or accumulation of starch, etc. Embryonic tissues generally have high water content and show most rapid division, differentiation and growth (*not* storage), etc.

masculinity, for as we shall see later a part of these females are strongly masculine, and indeed they show various grades of masculinity. The evidence against a differential maturation as a basis for an interpretation of the controlled sex ratios of pigeons is so strong as to cause its rejection, even if the essential constructive facts on the nature and basis of sex had not yet been learned.

The storage metabolism of many male- and female-producing ova, both in reference to egg of clutch and to position in the season, has been determined by means of the bomb calorimeter. The method is very accurate and the results are entirely convincing. The stored energy, or heat of combustion, of nearly 400 egg-yolks has been determined. One such series of determinations, (made in 1914) in which all available eggs of a particular female were burned is shown on Table 8. It will there be seen that the first clutch or pair of the season bore a higher caloric value than the second pair, but is otherwise the smallest of the year. Beginning with the second clutch laid in June the succeeding clutches to December 1 bear higher and higher heat values. In all clutches too, except the very first,[9] the second eggs show a higher storage of heat units than do the first of the clutch. Here we find the conclusions reached from studies on the wieghts of yolks, and on yolk analyses, fully confirmed by a method in which the error involved in the determination is wholly negligible. The most accurate method for the study of the storage metabolism of male and female producing ova give too the results most consistent with the breeding data. In other words, we could say, if we wished to make merry with our colleagues, the cytologists, that we here get closest to the facts of sex when we *burn* our chromosomes!

The energy values obtained from the burned yolks, permit an indirect comparison of the water values of the male- and female-producing eggs of the clutch. Such a comparison indicates, as in the chemical analyses, a higher percentage of

[9] Professor Whitman has observed that the very first egg in life or of the season is more likely to throw a *female* than is the first of the clutch of the immediately succeeding clutches.

water in the male-producing ovum. In addition to these two methods of studying the water values of the two kinds of eggs the value has been obtained direct, by desiccation, on a considerable number of samples. The three methods confirm each other. A little later we shall make a further application of the observed facts of higher water values, and of a higher metabolism in the male-producing ova.

Let us now very briefly consider the other kinds of observations that have been made on the series of eggs, from spring to autumn, produced under crowded reproduction by generic crosses, as these are schematically represented in Chart 1. Curves 2 and 3 on that chart represent facts which were first observed by Professor Whitman on these series of eggs. The curve entitled "developmental energy" (No. 2) represents the observed fact that more of the eggs of spring show the capacity to develop than do those of autumn; and by the use of a continuous (not broken) line or curve is indicated the further fact that the first eggs of the clutch bear throughout the season a similar relation (of higher fertility) to the second eggs of the clutch. The curve marked 3 and designated "length of life" tells again of an advantage possessed by the earlier hatched birds, and of a more limited life-term affixed to the hatches from the later "overworked" eggs. It is probable, moreover, that within the group of clutches giving rise to females only, a longer life-term falls to those birds arising from the first egg of the clutch than from those arising from the second of the clutch. Here, then, as in the preceding curve (2), the smaller eggs of both clutch and season are the eggs which give in their development the tests of "strength and vigor," while the larger eggs of clutch and season more often display "weakness."

The data which justify curves 4 and 5 as represented on the chart have already been considered. Of the observations upon which curve 6 is based we shall here say only that in general the weight of the parent bird is greatest at the season when the weights of the yolks being produced are smallest, and that when the largest yolks of autumn are being produced the weight of the parent bird is the smallest of the year. Tables 4 and 5

were prepared originally to make clear certain observations on size of off-spring in relation to their origin from eggs produced under overwork, after continued overwork, and in relation to the order of the eggs in the clutch. The tables themselves tell much of their story and we here forego a further consideration of them (see RIDDLE, '16, p. 406).

The seventh curve of Chart 1 refers to a long and rather large series of tests of the sex-behavior of series of birds such as those whose origin is indicated in Table 3 (series of 1908). We have here an opportunity to study and compare sex phenomena of particular birds whose sex we have reason to believe had been reversed from its initial sex-tendency; that is to say, where successive pairs of females have originated from successive pairs of eggs in the autumn, under overwork, we have the reasons already given for believing that some or most of such females arising from first eggs of the clutch have had their metabolism depressed to a point sufficient to make them females; but the second eggs of the *same* clutches should by the same means have been carried to a still more "feminine" level; and though both are females, it seemed possible to differentiate the one sort from the other, and this has been successfully done in a series of tests which now extend through a period of nearly five years. Each female has been given about nine tests, each of six months duration, with (for the most part) another *female*.

In this study, then, female is mated with female and male with male. Such pairs, from a very few selected pairs of parents, are kept mated for a period of six months. Most of the birds used, for lack of success with the incessantly fighting males, have been females, and most of the nine or ten successive tests with each bird have been made with her own sisters. The members of the pair are kept apart except when under observation; when put together, as is done twice daily, the records are taken of those females of the pair which behave as males in copulating with their mates. Three facts are definitely established by the data obtained: (1) The females of the *orientalis* × *alba* cross (they are dark in color) are more male-like in their sex behavior than the females of the reciprocal cross (these

are white in color). (2) Females hatched from eggs laid earlier in the season are more masculine in their sex behavior than are their own full sisters hatched later in the season. *And, several grades of females can be thus seriated according to season of hatching.* (3) The female hatched from the first egg of the clutch is more masculine than her sister hatched from the second of the clutch in a great majority of the cases. And in nearly all these latter matings the more masculine bird is so predominantly masculine that she takes the part of the male a full 100 per cent of the time in copulating with her very feminine clutch-mate sister. (See RIDDLE, '14*a*).

I may remark in passing that the effect of testicular and ovarian extracts (suspensions) have been studied in connection with the work on sex-behavior. The results have clearly shown that the sex behavior of a pair of females is modified by the intra-peritoneal injection of testis (pigeon) extract into the one and ovarian (pigeon) extract into the other. In one case, for example, the more "feminine" female of a pair was given testis extract and her more "masculine" mate received ovarian extract. After the injections the bird formerly more feminine, 16 copulations as a male to 23 by her consort, became very much the more masculine, 27 copulations as a male to only 2 by her consort.

To one other kind of fact concerning the effects of reproductive over-work in changing the developmental and sex phenomena of the germs of the later part of the season, we ask a moment's consideration.

It has been found that some females dead at relatively advanced ages show persistent right ovaries. The right ovary in pigeons normally begins degeneration at or before hatching and is usually wholly absent from the week-old squab. In our study it soon became evident that the persistent right ovaries were found almost exclusively in birds hatched from eggs of overworked series. Further study has shown in addition that they arise almost wholly from the eggs of autumn, and predominantly then from the second eggs of the clutch—that is from eggs otherwise known to have greatest or strongest

female-producing tendency. These ovaries have sometimes weighed half or more than half as much as the adult left ovary with which they were associated, and have been found in such birds dead at all periods from a few days to twenty-four months. We here attempt no adequate description of this situation, but one can not have observed the frequency of the persistence of this ovary in the birds hatched from the eggs otherwise known to be the most feminine from these overworked series, without conviction that the same pressure which carries the eggs of spring from male-producing to female-producing levels, also carries the earlier female-producing level to another yet more feminine.

The several kinds of facts just reviewed in connection with Chart 1 afford clear evidence that sex and characteristics other than sex such as fertility and developmental energy not only bear initial relations to the order of the egg in the clutch, but that sex and these other characteristics are *progressively modified* under stress of *reproductive overwork*, until at the extreme end of the season certain aspects of femininity are abnormally or unusually accentuated. In the light of these facts sex reveals itself as a quantitative modifiable character. And an association of modifiable metabolic levels with the flux and change of sex, or of sex ratios, has been found and described in precisely this same connection.

Let us now take these facts with us in a rapid survey of some experimentally induced and puzzling sex-ratios, and also into a brief consideration of some important facts of sex that have been learned from embryonic and post-natal stages of organisms.

The evidence that higher water values and higher metabolism are associated with male-producing eggs, lower water values with female-producing eggs, is of first importance in connection with our own generalization as to the germinal basis of sex-difference; and is further of much interest as being the means of demonstrating that in the—as I believe—several valid cases of sex-control now known, one thing in common has really been effected; this, though the work has been carried out on a considerable variety of animals and though the procedures have

themselves been most various. The thing that seems to have been effected in all cases has been the raising or lowering of the general metabolism of the treated germs. In probably none of the cases in which these experimentally induced abnormal sex-ratios were obtained—in other animals than the pigeon—has the observer been able definitely to eliminate all the possibilities of the continued determination of sex by the sex-chromosome; but several observers have been able to eliminate one or more of these possibilities for their material. And all of those experi-

TABLE 9

TIME OF FERTILIZATION AND THE SEX RATIO IN CATTLE

AUTHOR	TIME	♂: ♀	AUTHOR	TIME	♂: ♀
Thury and Cornaz	Early	0: 7	Russell	Early	31: 51
	Late	22: 0		Late	42: 34
Düsing[a]	Early	8: 10	Pearl and Parshley	Early	123: 125
	Late	4: 1		Middle	67: 58
Düsing[a]	Early	3: 10		Late	65: 42
	Late	1: 1			

Total[b]	Early	134: 178, ratio =	75.3 ♂: 100 ♀
	Middle	67: 58, ratio =	115.5 ♂: 100 ♀
	Late	77: 44, ratio =	175.0 ♂: 100 ♀

[a] Work cited by Düsing.

[b] Omitting the data submitted by Cornaz in the first announcement of the theory.

ments which strongly suggest a real sex reversal or control can now be shown to be in alignment with one or more of the basic facts of sex control now known in the doves and pigeons. When the conditions of these experiments have been such as to lead us to expect an *increase of the metabolism*, males have been produced in excess, and when the conditions imposed have been obviously capable of *depressing the metabolism* of the treated germs, these have yielded an excess of females. These facts, therefore, afford much reason for the opinion that sex has been controlled or reversed in a number of very different animals.

The observed relation of the time of fertilization to modified sex-ratios in cattle is summarized in Table 9. Thury reported in 1862 that from fertilizations made in the early period of heat in cattle an excess of females were produced; and that later (delayed) fertilizations give rise to an excess (*all* according to Thury) of males. Similar experiments have been several times repeated and these repetitions have all shown an excess of one or the other sex in accordance with such early or late fertilization.[10] The facts as reported by the several observers, and the totals, are given in the table. We postpone for a moment a discussion of the situation presented by these data except to

TABLE 10

TIME OF FERTILIZATION AND SEX RATIO IN SHEEP

Bell[a]	Matings in October, 1899	♂ 10: ♀ 26	= 72.0 per cent ♀
	Matings time unknown, 1899	♂ 179: ♀ 166	= 48.0 per cent ♀
	Matings after November 15, 1899	♂ 23: ♀ 3	= 11.5 per cent ♀

[a] Records of a neighboring flock supplied to Dr. Bell by Mr. Macrae.

draw attention to the probability that in late (delayed) fertilization the ovum *takes up* water before fertilization and gives an excess of males.

Connected with these facts obtained from cattle are some partially similar data for sheep. From records obtained by Dr. Alexander Graham Bell ('14), made primarily with the object of learning whether certain conditions have an influence on "twinning" in sheep, the materials for Table 10 have been taken. Here, again, as in cattle there is probably some evidence for an increased male production from delayed fertilizations.

Experiments on the frog and the toad have afforded evidence for the control of sex. Richard Hertwig ('06, '12), and later Kuschekewitch ('10), allowed frog's eggs before fertilization to "overripen," a process during which *the eggs take up water*—

[10] The use of the terms *early* and *late* fertilizations assume that some ovulation occurs either immediately before, or shortly after, the beginning of heat.

and obtained (the latter author) in some cases a total of 100 per cent males (Table 11). Dr. King ('12) did the converse of this experiment with toad's eggs—withdrawing water from them before fertilization—and obtained nearly or quite 80 per cent of females in cases where the mortality was less than 7 per cent.

The evidence afforded by these experiments on the frog and the toad is thought by many to be inconclusive as evidence for real sex control. Though selective fertilization has been eliminated as a possibility by Kuschekewitch, we do not know which is the heterogametic sex in amphibia and there also remains the

TABLE 11

EXPERIMENTALLY MODIFIED SEX RATIOS IN FROGS AND TOADS

AUTHOR		TREATMENT	RESULT		♂
			♂	♀	
					per cent
Hertwig, R.....	frog	Delayed fertil. (+ H_2O)	271	0	100.00
			...	...	88.88
Kuschekewitch		Delayed fertil. (+ H_2O)	299	0	100.00
King, H. D.....	toad	No delay + H_2O	62	41	60.20
		No delay − H_2O	106	275	27.66
			85	289	22.73

possibility of parthenogenetic development to account for the excessive male-production in the experiments with the frog. But this appeal makes it impossible to explain the great excess of *females* obtained by Dr. King on the eggs of the toad, where a selective mortality is definitely excluded, and leaves such doubters to lean upon the rather discredited staff of selective fertilization—a proposition wholly disproved for the related frog and for the pigeon. It may be noted, however, that on the basis of our present knowledge of the "sex-differentials" (to be considered later) in the pigeon's eggs both of these experiments

might have been predicted to result as these three investigators have reported.

The modified sex ratios obtained from the four types of animals just mentioned were all obtained through action upon the eggs, or the egg-stage of the organisms. Some important experimental work, and other very significant physiological and chemical study, has been done on sex in the embryonic and adult

CHART 2

Bonellia; Free-martin; Inachus; Frog; Pigeon; Duck; Fowl; Pheasant; Sheep; Human; Stag.

Egg

- Cow — ♂ high per cent H_2O (?); ♀ low per cent (H_2O (?)
- Pigeon → *Adult*
  - ♂: low fat and P.; HIGH METABOLISM; high per cent H_2O
  - ♀: high fat and P.; LOW METABOLISM; low per cent H_2O
- Frog / Toad — ♂ high per cent H_2O; ♀ low per cent H_2O

Adult

- Human
  - ♂: (blood) low per cent fat; HIGH METABOLISM
  - ♀: (blood) high per cent fat; LOW METABOLISM
- Fowl — ♂ (blood) low fat and P.; ♀ (blood) high fat and P.
- Crab — ♂ (blood) low per cent fat; ♀ (blood) high per cent fat

Hydatina — ♂'s from change of food and increased oxygen supply. ♀'s from unchanged food and lesser oxygen supply.

Daphnids — sex-intermediates—sexual or asexual reproduction influenced by conditions.

Moths — sex-intermediates—quantitative germinal basis.

stages of the organism. Something can here be gained by grouping and treating these several results in a single diagram.

Now that the basic problem of sex has been shown to be essentially a question of metabolism, a department of physiology and biochemistry, we shall be able to note in connection with Chart 2 (where the principal known facts concerning the relation of metabolism to sex are diagrammatically arranged) that a num-

ber of data bearing on adult sexual differance of the sort we most require are already at hand.

Turning now to the diagram we note that *egg* and *adult* stages are first distinguished. In the *egg* of the pigeon we have identified maleness and femaleness by three differentials. Femaleness in the egg-stage being accompanied by *low metabolism*, lower percentage of water, and higher total fat and phosphorus, or of phosphatides. Maleness is here accompanied by high metabolism, higher percentage of water, and lower total fat and phosphatides. Now there are valid reasons for treating these three differentials not as separate and disconnected facts, but rather as aspects or corollaries of the same fact. For example, a

TABLE 12

SEXUAL DIFFERENCES OF FAT AND PHOSPHORUS IN THE BLOOD OF ADULT FOWLS AND OF MAN

SEX	AVERAGE TOTAL FAT	AVERAGE TOTAL PHOSPHORUS	RELATIVE AMOUNTS OF PHOSPHORUS
Males (roosters)	15.45	6.43	100
Non-laying females	17.87	7.42	115
Laying females	27.80	13.15	205
Males (man)	141.4		
Females (women)	226.0		

high metabolism in a cell is consonant with less storage of fat and phosphatides, and with a more *highly hydrated state* of the cell-colloids. It follows that where data for either of these three differentials are at hand, for either the germ or adult of any animal, we have in such data evidence of the kind we are looking for, i.e., evidence for the association of a given type of metabolism with the germ or adult of a given sex.

For what forms then are such data available? And, what is now known of the *persistence* of this definite type of differentiation of the two kinds of sex germs into *adult stages* of the two sexes? Recently, in my laboratory in coöperation with Mr. Lawrence ('16), it has been shown that one of these differentials

—or one aspect of *the* differential which our own work has demonstrated in the egg—is clearly continued in the *blood* of the adult male and female. Fowls were substituted for doves in this case in order to increase the size of the samples and thus increase the accuracy of the analytical results. The blood of the male contains less fat and less phosphorus—just as the male-producing egg contains less of these same elements. The data further show that the sexually active (or actively functional) females depart most widely from the male, while sexually inactive females occupy an intermediate position in respect of the amounts of these constituents found in the blood (see Table 12).

The results afford fairly clear evidence that in birds *the metabolic differences of male and female germs persist in the male and female adults.*

In mammals too these aspects of sexual differences of the adults have been fully demonstrated. Almost simultaneously with the above determinations on birds, data were published by Goettler and Baker ('16) which (as we have pointed out, '16) show that the blood of the human male contains less fat, that of the female more. Further, the *basal metabolism* of the human male and female has recently been accurately determined by Benedict and Emmes ('15); they find that the metabolism of man is 5 to 6 per cent higher than that of woman.

Have we any measure of either of our differentials in any mammalian *egg?* I think that the experiments on sex-determination in cattle, together with an observation by van der Stricht, afford some evidence that the water content of the male-producing egg is high, and that of the female-producing egg is low. No one definitely knows whether the ovum of the cow absorbs water in the Fallopian tubes in this interval between ovulation and fertilization, but we do know that every amphibian, reptilian, and avian egg that has been investigated does absorb very appreciable amounts of water while being passed from the ovary to the exterior. And van der Stricht has described phenomena of growth or swelling of the yolk-granules of one mammal—the bat—which, I am sure from my own studies on yolk, indicate the taking up of water by the egg of this mam-

mal. It is highly probable, therefore, that precisely that *time relation* which leads to an excess of males in cattle is preceded or accompanied by an increased hydration of the ovum. In mammals therefore there is some evidence that a shift of the metabolic level—as indicated by one partly known differential—is associated with the observed changes in the sex-ratio of the germs which are thus modified. Further, in the adult of one mammal—man—two of the three sex-differentials have been definitely demonstrated. These results for both the egg and adult stages of the mammal are at every point in complete agreement with our data for both the egg and adult stages of the bird.

How now do the controlled sex ratios obtained in the frogs and toads appear in the light of the sex differentials of our diagram? Clearly the data given in Table 11 arrange themselves in perfect agreement with the metabolic differentials which obtain in birds and mammals. The data of that table eliminate "delayed fertilization" *as such* as being a factor and show that the altered sex ratios correspond with increase or decrease of water as the *sole known* differential.

We next give a moment's consideration to an adult stage in which a change in metabolism was observed in connection with sexual changes. In the spider-crabs Geoffrey Smith ('11) showed that both the blood and the liver of the adult male crabs contain less fat than do the blood and liver of the females. Here once more the facts concerning one of the sex-differentials is known and is in complete accord with all the preceding cases. In these spider-crabs, known to be sometimes castrated by parasites, Smith and Robson were able to show, moreover, that the *parasitized male crabs, which under these conditions gradually assume several female morphological characteristics, are also found to have assumed the type of fat metabolism which characterizes the normal female crab.* How much these facts contribute to, and how completely they adjust themselves to, our own general theory, will be realized only after a moment's reflection. Recently Kornhauser ('16) has found some of these conditions also in *Thelia.*

A glance at the diagram indicates three other groups of animals which experimental work has thrown into the general question of the control of sex. The information at hand for these forms does not so expressly concern the *egg* as does that from the preceding cases, but all of these latter groups are concerned with early stages—some of them with the generation preceding the egg whose sex seems influenced by conditions. The results of studies of the first of these groups—Hydatina—are of such a kind as to show that they are in general accord with the metabolic differentials of all of the previously mentioned cases of sex-control. One can scarcely doubt that *change* of food and *increased* oxygen supply are consonant with increased metabolism, just as the studies of Whitney ('14 and later) particularly, and later of Shull ('16), have shown that these changes lead to the production of male-producing daughters.

The second of these groups—the Daphnids—have been studied by three independent investigators who agree upon two points that are of importance in the question of the control of sex, and to the general theory of sex as stated here, though the results throw little light on precisely what is causally involved. Issakowitch ('05), Woltereck ('11), and Banta ('15) all find numerous *sex-intergrades* in a material in which all agree that the type of reproduction—sexual or asexual—is influenced by environmental conditions. All further agree that "unfavorable conditions" (or is it a *change* from favorable conditions?) tends toward *sexual* reproduction, while "favorable conditions" favor asexual reproduction.

In the third of these groups—the moths—the studies of Goldschmidt ('12, '14), Goldschmidt and Poppelbaum ('14), Harrison and Doncaster ('14), and the work of Machida, have demstrated again sex-intermediates of various grades. Moreover, it has been shown that from among the various geographical races of moths certain matings can be arranged which produce rather definite types of male- or female-intermediates—or sex-intergrades as Goldschmidt elects to call them. And further, from pairs involving still other species still other levels or grades of sex-intermediates may be freely obtained. A more or less fac-

torial basis of the phenomena has hitherto been used in the discussion of these results; but recently Goldschmidt ('16) has stated that "very important new facts will be published later which will probably enable us to replace the symbolistic Mendelian language, used here, by more definite physico-chemical conceptions." Such newer descriptions—we would say—is wholly in line with the requirements of present data on sex. In Whitman's and our own material it has been clear from the first that the results far overstep the possibility of treating them in Mendelian terms, for it has been apparent from the beginning that we have had to do not with three or four points merely, but with a *flowing graduated line*. In the work with the moths, however, sex is clearly described in *quantitative* terms, and it seems fairly certain that when the functional basis of sex shall have been identified it will be found that sex accords with metabolic grades there, as it does elsewhere.

It is clear then that all of the animal-forms for which there is reasonable evidence of sex-control show important correspondences with the situation fully elucidated in the pigeons. And that where the sex-differentials known to exist in the pigeon's ova have been traced in adults of the two sexes, the parallel rigorously holds there also. A general classification of male and female adult animals on the basis of a higher metabolism for the one and a lower for the other, was indeed made by Geddes and Thomson ('90) many years ago. It now seems beyond question that this conclusion of these authors is a correct and important one.

It remains to point out that another very old and much worked line of investigation supplies further confirmatory evidence for our present point of view. Studies on the effects of castration, gonad-transplantation, and gonad-extract injection, constitute a large body of observations which deal with sexual phenomena associated with the *internal secretions* of the sex-glands. These internal secretions, let it be remembered, are themselves *metabolites*, which have the capacity to *influence the metabolism* of some, many, or of all the tissues with which they

come in contact or which they may reach indirectly.[11] A partial list of the animal forms that have been most studied in this respect is written serially on the top of our diagram—in a position intermediate to egg and adult. The number of these animal forms might be much increased, and the names of the investigators of this aspect of the modification of sex are quite too numerous[12] to be mentioned here. But the present point of interest is that these results, as a whole, demonstrate that *the extent of sexual modification in the experimental animal is, in general, in proportion to the immaturity of the treated animal.* That is to say, the earlier the internal secretion of the gonad is supplied or withdrawn—the earlier the metabolic change is effected—the more profound is the sexual modification of the individual. All this is of course clearly in conformity with the Law of Genetic Restriction—a principle of embryology that is true alike for all of the known characteristics of the organism.

Of the several animals of the list we may here particularize concerning only two or three. The stag is a form that has long been known to show thus a considerable and beautiful series of greater modification of antlers and other so-called secondary sexual characters, in correspondence with castration at earlier and earlier periods in the life of the animal. The free-martin —another Ungulate—is now known to exemplify a much earlier point at which the foreign internal secretion begins to act;

[11] That changes following the removal of gonads, etc., have for many years been recognized as connected with a changed *metabolism* may be illustrated from the following quotation from Marshall ('10). "The effects of castration indicate that an alteration in the metabolism, even in comparatively late life, may initiate changes in the direction of the opposite sex" (p. 658).

[12] The following partial references are suggested by the particular animals listed in the diagram: *Stag*, DARWIN (1868); CATON (1881); FOWLER (1894); RÖRIG (1900). *Human*, HEGAR (1893); SELHEIM (1898); HIKMET and RENAULT (1906); C. WALLACE (1907); TANDLER and GROSS (1909). *Sheep*, SHATTOCK and SELIGMAN (1904); SELIGMAN (1906); MARSHALL and HAMMOND (1914). *Guinea-pig*, BOUIN and ANCEL (1903–9); STEINACH (1910–13). *Pheasant*, GURNEY (1888). *Fowl* and *Duck*, DARWIN (1868); GURNEY (1888); FOGES (1903); SHATTOCK and SELIGMAN (1906–7); GOODALE (1910–16). *Pigeon*, RIDDLE (1914 *a*). *Frog*, NUSSBAUM (1907); PFLÜGER (1907); STEINACH (1910); G. SMITH (1912). *Inachus* and *Carcinus*, POTTS (1909); G. SMITH (1910–12). *Free-martin*, LILLIE (1916). *Bonellia*, BALTZER (1914).

and here, true to the rule that has been established elsewhere in all this general line of work, the resulting modification is correspondingly strong and striking. When, by whatever means, we effect a change in the metabolism (which is the essential thing) at a still earlier stage—in the egg-stage in our own and in some other experimental reversals of sex—then we obtain individuals whose sexual nature is quite thoroughly reversed;[13] in many cases completely so, and in still other cases with varying degrees of completeness.

Baltzer's ('14) beautiful experiments with the worm Bonellia best illustrate this fact and show the several stages of modification not only in one and the same animal form but in the individuals hatching from a single brood. Baltzer finds that when the larvae of this animal are hatched they are capable of becoming either males or females. If they happen to become attached to the proboscis of an adult female they become males; if they do not succeed in so attaching themselves they soon settle from the water into the sand or mud of the sea-bottom and there undergo, quite slowly, further development into *females* (almost exclusively). The plastic, reversible, quantitative nature of sex in this form was shown by this investigator in the following way: Some of the free-swimming "indifferent" larvae were artificially helped to a connection with the proboscis of an adult female. Some of these were permitted to maintain this attachment for a very short period; others were removed at progressively longer periods, with the very significant result that practically all stages of hermaphroditism were produced. Those first removed becoming almost perfect females, others with longer and longer periods of attachment, becoming more and more perfect males.

Now the conditions under which the two sexes are here developed afford, in our own opinion, good reasons for believing that the larva is stimulated—through its contact with the living

[13] The observations of Steche ('12) on the relation of *precipitin* reactions to sex, as seen in the blood of insects are of much interest. This author thus finds that male and female of the same species present differences as great as do the males of two related species, or as do the females of related species.

tissue—to a *higher* metabolism; supporting this point of view is the observed fact that "differentiation" is much hastened in this male individual as compared with the otherwise wholly similar larva that is destined to become a female.

What it has been our privilege and opportunity to present is in itself but an outline or summary of result obtained in the modification and control of sex, and of the conclusions that seem to follow from these results. In a closing statement, therefore, we wish only to direct attention to some consequences of the new knowledge of sex. As a foreword to this statement, however, we would note that not only do the widely different kinds of fact to which we have made reference directly support the view of the basis of sex here presented, but that nothing known of the sex-chromosomes is necessarily opposed to this view although an abundance of the data here presented sharply oppose the conception that the sex-chromosomes are a *cause* of sex, or that they are even a necessary associated phenomenon. We may conceive that sexually differentiated organisms, from the first, have had the problem of producing germs pitched at two different metabolic levels; and if two sharply opposed sexes are to result from these two kinds of germs then the two metabolic levels must be measurably distinct. This task of producing and maintaining two kinds of cells pitched at two different levels ultimately falls upon *cells*, and these have, sometimes at least, produced two different chromosome complexes in connection with or in accomodation to the establishment of these two metabolic levels. But, as we have seen, the requisite metabolic level of the germ may be established in the absence of the appropriate chromosome complex, and the sex of the offspring made to correspond with the acquired grade or level of metabolism.

With these facts concerning the functional basis of sex in mind, and reverting to our first quotation from Doncaster, how little wonder that sex (despite its seeming "lack of function" is "nearly universally distributed," almost coequal with "the fundamental attributes of living matter, irritability, assimilation and growth?" Since *some* grade of metabolism is of necessity universally present in living matter the basis for two

sexes is of equally wide distribution in that sexual differentiation results from metabolic differentiation, through the establishment of two relatively distinct and relatively stable levels of metabolism. In the same way is accounted for the hitherto puzzling fact that the two sexes must have originated many times, scores, hundreds, or thousands of times, within species previously unisexual, during the long period involved in the evolutional history of organisms.

Most important of all, perhaps, is the demonstration that one *hereditary* character is modifiable, is of a fluid, quantitative, reversible nature. Seemingly this can only mean that other hereditary characters are also modifiable. The methods and results of most studies in modern genetics have asked us to accept a quite different view, namely that no such thing as control of heredity may be hoped for, but that we can only look to a sorting and elimination of germs, or of so-called hereditary factors—and to fortuitous origins or recombinations of the latter—to give us better or more desirable organisms. Surely there is a lot of fatalistic philosophy in that conception. All other aspects of function in biology recognize—and some have already attained—the *control* of life-processes as their aim and goal. Only in this field of heredity—involving the overwhelmingly important processes of continuance and of becoming—has this aim been accepted by a great and growing body of workers as impossible. If sex has been in fact controlled, if it has a modifiable metabolic basis—as now seems assured—then the life processes involved in heredity like other life-processes, invite the investigator to his full and complete task; territory hitherto labelled "impossible" is open to investigation.

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ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Tungsten deposits of northwestern Inyo County, California.* ADOLPH KNOPF. U. S. Geological Survey Bulletin 640-L. Pp. 21. 1917.

Tungsten deposits were found in northwestern Inyo County, California, in 1913 but remained practically unknown until the spring of 1916, when they began to be energetically developed. By midsummer two mills, having a total daily capacity of 400 tons, had been completed and were in active operation.

The ore consists of scheelite associated mainly with garnet, epidote, and quartz. The country rock is prevailingly granitic, but in it are isolated masses of limestone which became mineralized shortly after the granitic rocks were intruded. The limestones were altered to masses of garnet carrying subordinate scheelite by the metallic vapors then given off, and these altered rocks are the tungsten deposits now under exploration. The ore bodies that are being mined are from 20 to 60 feet wide and from 150 to 260 feet long. They carry from 1.5 to 2 per cent of tungsten trioxide (WO_3). The area in which scheelite-bearing deposits have been found forms roughly a belt 20 miles long, but it is likely that the prospecting now going on will extend the dimensions of the field.

These deposits, like those discovered in recent years in Humboldt County, Nevada, belong to the contact-metamorphic class, a well-known source of copper and iron but not widely recognized as a possible source of tungsten. A. K.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 570th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, April 21, 1917; called to order at 8 p.m. by President HAY; thirty-five persons in attendance.

On recommendation of the Council, S. S. VORHEES of the Bureau of Standards was elected to membership.

Two communications were presented:

A. H. HOWELL: *Notes on American flying squirrels.* Mr. Howell spoke first of the general zoologic position of flying squirrels, then of their external characters and habits, their mode of "flight," food requirements, etc. He gave a brief résumé of the generic names that have been applied to the American flying squirrels. The main part of Mr. Howell's paper dealt with his recent systematic study of the group, a consideration of the various species and subspecies, their interrelationships and geographic distribution. Maps showing the distribution of all the American forms were exhibited as well as skins of the more important members of the genus. W. P. TAYLOR, A. WETMORE, R. W. SHUFELDT, and W. P. HAY took part in the discussion, in which it was brought out that flying squirrels have apparently no natural enemies save certain owls, and that extraordinary numbers of individuals of flying squirrels, at least several dozens, may be found inhabiting a single tree.

O. P. HAY: *On the finding of supposed Pleistocene human remains at Vero, Florida.*

Having described the geography, topography, and geology of the region about Vero, the speaker presented his conclusions.[1]

1. The problems to be solved at Vero concern primarily the geologists and paleontologists; only secondarily the anthropologists. For, little that is certain is yet known about the beginning and the course of human history on this continent.

2. Because of the small number of bones belonging to each human skeleton found at Vero and their scattered condition, it is unreasonable to suppose that they were purposely buried where found.

3. These bones must have reached their recent positions before the deposition of the muck layer, Sellard's No. 3, unless human bones possess some unexplained means of underground dispersal.

[1] In order to understand the matters involved consult Journ. Geol., **25**: 1–62. 1917.

4. The Pleistocene fossils in No. 2 are there because the animals died there. They were not washed in from the region further back, principally because there were no fossils there to be washed in.

5. The Pleistocene fossils of No. 2 belong to the early Pleistocene, as shown by the character of the species and the high percentage (74) of the extinct forms.

6. The Pleistocene fossils in No. 3 represent animals which died there. They were not washed in from above. They were not washed up from No. 2, because of (*a*) frequent association of parts of the same skeleton, (*b*) the good state of preservation, (*c*) the early protection of No. 2 from erosion by the blanket of muck, No. 3.

7. So far as determined, the extinct species in No. 3 form about 44 per cent of the whole number—almost exactly the same as in the case of the Conard fissure in Arkansas. The fauna just referred to probably belongs to the Illinoian stage.

8. Possibly the geological conditions may permit the conclusion that some parts of No. 2 were reworked about the middle of the Pleistocene and that then the human bones were included.

9. There are independent evidences that man with a culture much like that of modern Indians existed in America during approximately the Sangamon stage. Some of these are:

a. The finding of a human pelvis below the loess at Natchez and associated with extinct animals.[2]

b. The discovery of flint arrow-heads at Muscatine, Iowa.[3]

c. The finding, at Muscatine, of flint chips at a depth of 10 feet in a gravel bed from which an elephant tooth had been taken.[4]

d. The discovery of a stone axe at Council Bluffs in loess at a depth of 35 feet.[5]

e. The finding of a stone axe near St. Louis in loess at a depth of 14 feet.[6]

f. The finding of a flint arrow-head under the scapula of an extinct bison in Kansas by Mr. H. T. Martin.[7]

We may not be able to rely absolutely on any one of these reputed finds; but taken together they are cumulative and produce a probability of man's existence in Pleistocene times.

10. Man had his origin probably in southern Asia. From this region, and not from Europe, were peopled the other continents and the islands of the seas. A people as advanced as many modern Indians may have reached America long before the Cro-Magnons had been able to dispossess the fierce Heidelbergers and Neanderthalers who had preoccupied Europe.

[2] DICKESON. Proc. Phila. Acad., **3**: 106. 1896.

[3] WITTER. Proc. Iowa Acad. Sci., **1890–1891**: 67.

[4] Op. cit.

[5] UDDEN. Iowa Geol. Surv., **11**: 261.

[6] PETERSON. Record of the Past, **2**: 26.

[7] Amer. Geol., **30**: 313.

11. There seems to be no good reason why some races of man might not, very early in the Pleistocene, have reached a physical development quite equal to that of today. Such was the case with the horses, the oxen, the bears, the dogs, and many other forms.

Dr. Hay's remarks were illustrated by lantern slide views of the deposits.

M. W. LYON, JR., *Recording Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 511th regular and 38th annual meeting of the society was held at the New National Museum on April 17. After approving the reports of the secretary, treasurer, and auditing committee the society elected the following officers for the ensuing year: *President,* Mr. WILLIAM H. BABCOCK; *Vice-President,* Mr. FRANCIS LAFLESCHE; *Secretary,* Miss FRANCES DENSMORE; *Treasurer,* Mr. C. N. B. HEWITT; *Councillors,* Mr. E. T. WILLIAMS, Mr. NEIL M. JUDD, Dr. TRUMAN MICHELSON, Mr. FELIX NEUMANN, and Dr. I. M. CASANOWICZ.

Memorials to members of the society deceased during the past year were then presented. A sketch of the life of Gen. ELLIS SPEAR, an active member of the society, was read by Mr. W. H. BABCOCK. The memorial to Mr. S. M. GRONBERGER, an associate member, was prepared and presented by Mr. JAMES MOONEY, and that to Mr. J. D. MCGUIRE, an honorary member, was prepared and read by Dr. J. W. FEWKES. Tributes to Prof. JOHANNES RANKE and Prof. GUSTAVE SCHWALBE of Germany, honorary members, were given by Dr. ALEŠ HRDLIČKA, and a review of the life and work of Sir EDWARD BURNETT TYLOR, a corresponding member of the society, was read by Dr. JOHN R. SWANTON; tributes to Dr. TYLOR being also given by Dr. TRUMAN MICHELSON and Dr. LEO J. FRACHTENBERG.

FRANCES DENSMORE, *Secretary.*

VIN